# PATENT SPECIFICATION

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## (54) CATALYTIC ELEMENT FOR CATALYTIC CONVERTER

(71) We, TENNECO INC., a Corporation organized and existing under the laws of the State of Delaware, United States of America of 1201 Michigan Boulevard, Racine, Wisconsin, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a catalyst unit for use in the exhaust system of an internal combustion engine.

It is a purpose of this invention to provide a means to increase the effectiveness of and decrease the rate of deterioration of monolithic catalyst elements such as shown in United States Patent Specification No. 3,441,381.

According to the invention there is provided a catalyst unit adapted for use in the exhaust system of an internal combustion engine and comprising a tubular housing having a longitudinal axis, said housing having an inlet at one longitudinal end and an outlet at the other longitudinal end, a monolithic honeycomb catalyst element supported in the housing and having longitudinally extending passages through which exhaust gas must flow to pass from the inlet to the outlet, said element having an inlet end face and an outlet end face into which said passages open and through which gas flows in use of the unit, the end faces of said element being shaped so that the passages are non-unform in length with the longest passages being located adjacent the longitudinal axis and the shortest passages being located adjacent the outer periphery of the element and remote from said longitudinal axis.

The invention will be further described by way of example, with reference to the accompanying drawing, wherein:

FIGURE 1 is a schematic side elevation, partly broken away and partly in section, of an automobile engine having a catalytic exhaust system containing a catalyst unit embodying the invention;

FIGURE 2 is a broken away longitudinal section of a conduit showing a typical gas velocity profile;

FIGURE 3 is an enlarged broken away section of the catalyst unit of Figure 1;

FIGURE 4 is a section similar to Figure 3 but showing a modification;

FIGURE 5 is a cross section along the line 5—5 of Figure 3; and

FIGURE 6 is a side elevation of a further modified catalyst element.

Referring to the drawings, an internal combustion engine 1 has an exhaust manifold 3 which discharges gas through its outlet 5 into the inlet or exhaust conduit 7 of an exhaust system 9 containing a catalyst unit 11. The unit 11 discharges into a conduit 13 that may carry the exhaust gases to another device in the system or to atmosphere. The system shown is intended especially to represent an automotive exhaust system but the invention may be used in connection with catalyst units for various other internal combustion engine exhaust systems.

The catalyst unit 11 has a tubular (circular) outer shell 15 that extends between and is secured to an inlet cone 17 and an outlet cone 19 which, respectively, are secured to conduits 7 and 13. A cylindrical, monolithic, homeycomb catalyst element 21 is coaxially supported by a resilient sleeve 23 inside the shell 15 and has ~~an~~ inlet face 25 receiving gas from the pipe 7 and an outlet face 27 from which the gas is discharged into the pipe 13.

The element 21 comprises a relatively brittle monolithic honeycomb refractory material with longitudinal cells, channels, or passages 29 extending through it from the inlet to the outlet face. Catalyst material is deposited on the walls of the passages and promotes the conversion of undesirable constituents in the exhaust gas flowing through the element. Heat is released to a

greater or lesser degree in the element, depending upon the constituents converted, but in all cases the temperature along the centre axis of the element is several hundred degrees higher than ambient temperature surrounding the unit 11. The temperature of each channel 29 is a function of the amount of gas passing through it so uneven flow distribution promotes differential expansion of the element which results in forces tending to cause cracking and deterioration of the brittle refractory material. As illustrated by the velocity profile 31 of Figure 2, the gas flow through a round pipe is non-uniform with the maximum velocity being at the centre of the conduit and the minimum along the wall; and this velocity differential increases with the rate of flow. Thus, the inherent nature of gas flow tends to promote deterioration of the brittle element 21.

It has been determined that a catalytic system using a monolithic element, such as element 21, is most efficient when the space velocity of gas flowing through it is uniform, i.e. when all parts of the element pass equal volumes of gas per unit of time. In prior art elements, the inlet and outlet faces 25 and 27 are planar, parallel, and perpendicular to the axis of the element 21. Considering the shape of the velocity profile 31, it will be seen that the natural non-uniform flow distribution will result in low efficiency of operation of the catalyst.

These deficiencies, low efficiency and tendency toward deterioration, are counteracted in the present unit by convexly contouring one or both of the faces 25 and 27 to produce a more uniform residence time for gas in the channels 29. The convex contour, in directions transverse to the longitudinal axis of the unit, comprises a surface of revolution about the axis of the unit, provides longer channels at the centre of the element where the gas velocity is greatest and shorter channels at the outer portions where the gas velocity is at a minimum. The variation in length matches inversely as closely as practicable the variation in velocity across the diameter of the element at a particular preselected volume flow rate of the exhaust gas. The non-uniformity of profile 31 is directly related to volume of flow and since flow rates vary widely in automotive applications, the contours are selected for a particular vehicle speed, normally in the range of 25—35 mph, for which maximum catalyst efficiency is most desirable.

In accordance with these concepts the inlet face 25 of element 21 is convexly shaped to be substantially the inverse of profile 31, thereby providing a substantially uniform time for gas to pass through the element at the speed for which the profile 31 is calculated. Figure 4 shows the reverse arrangement in which the outlet face 27′ is modified element 21′ is convexly contoured substantially to duplicate the shape of a different and shallower velocity profile as produced at a lower speed. Obviously, both end faces could be convexly contoured to produce the desired different lengths of channels 29′′ as indicated by ends 25′′ and 27′′ for element 21′′ in Figure 6.

The convex inlet face 25 of Figure 3 is at present thought to be desirable for another reason. It projects into the incoming gas stream and is entirely surrounded by gas, as distinct from the portion downstream thereof wherein the outer surface is surrounded by the insulating, resilient layer 23. Thus, the face will have a tendency on start-up of the engine to reach ignition temperature of the catalyst somewhat faster than would the conventional flat inlet face 25′ of Figure 4.

Thus, it will be seen that there has been described means to improve the performance of a monolithic catalyst element and decrease the harmful effects of differential expansion by contouring one or both end faces of the element to provide more uniform flow and gas residence time across a cross-section of the element.

WHAT WE CLAIM IS:—

1. A catalyst unit adapted for use in the exhaust system of an internal combustion engine and comprising a tubular housing having a longitudinal axis, said housing having an inlet at one longitudinal end and an outlet at the other longitudinal end, a monolithic honeycomb catalyst element supported in the housing and having longitudinally extending passages through which exhaust gas must flow to pass from the inlet to the outlet, said element having an inlet end face and an outlet end face into which said passages open and through which gas flows in use of the unit, the end faces of said element being shaped so that the passages are non-uniform in length with the longest passages being located adjacent the longitudinal axis and the shortest passages being located adjacent the outer periphery of the element and remote from said longitudinal axis.

2. A catalyst unit as claimed in claim 1, wherein at least one of the end faces is convex in directions transverse to the longitudinal axis.

3. A catalyst unit as claimed in claim 1, wherein the inlet end face of the element is convex.

4. A catalyst unit as claimed in claim 1 or 2, wherein the outlet end face of the element is convex.

5. A catalyst unit as claimed in any

preceding claim, wherein at least one of the end faces comprises a convex surface of revolution about the longitudinal axis of the unit.

6. A catalyst unit as claimed in any preceding claim, wherein one of the end faces is shaped substantially to correspond with the velocity profile of gas flowing through the unit at a preselected volume rate.

7. A catalyst unit as claimed in any preceding claim, wherein the lengths of the passages are related to the velocity profile of gas flowing to the element at a particular volume flow rate so that the residence time of gas in the passages is substantially the same for all passages.

8. A catalyst unit constructed and arranged substantially as herein described with reference to and as illustrated in the accompanying drawing.

9. An internal combustion engine exhaust system embodying a catalyst unit according to any preceding claim.

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1455351 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

FIG. 1.

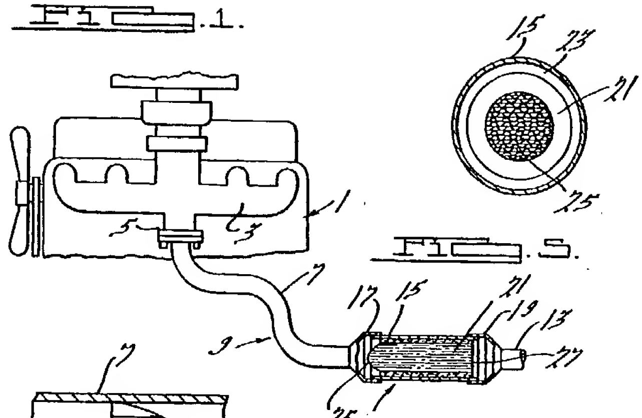


FIG. 5.

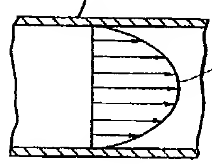


FIG. 2.

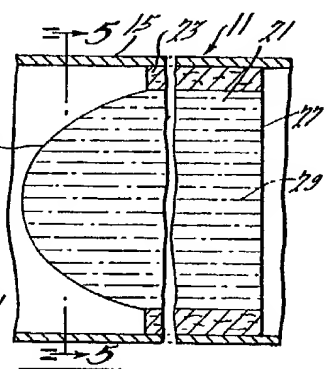


FIG. 3.

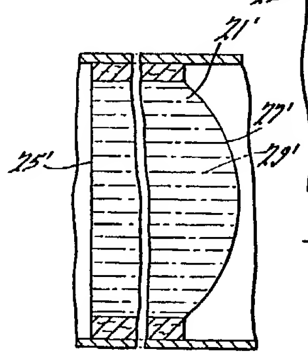


FIG. 4.

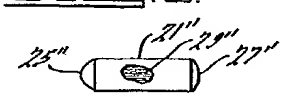


FIG. 6.